

**Implementation of Wireless Enhanced 911 in
Kingsport, Tennessee**

**for
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Abstract:

For many Americans, the ability to call 911 for help in an emergency is one of the main reasons they own a wireless phone. Prompt delivery of these and other wireless 911 calls to public safety organizations benefits the public by promoting safety of life and property. While wireless phones can be important public safety tools, they also create unique challenges for public safety organizations and emergency response personnel. Unlike a traditional landline phone, a caller using a wireless phone could be calling from anywhere. This presents life threatening problems due to lost response time if callers are unable to speak, don't know where they are, don't know their wireless phone callback number, or if the call is dropped. In order to resolve this situation the Federal Communications Commission (FCC) has taken a number of steps to increase public safety by encouraging and coordinating development of a nationwide seamless communications system for emergency services that includes the provision of location information for wireless 911 calls. The FCC's Wireless 911 rules are being implemented in stages. Phase 2 requires wireless carriers to begin providing more precise location information to Public Safety Answering Points (PSAP), specifically, the latitude and longitude of the caller. Kingsport's Central Dispatch needed to implement a plan that would be capable of meeting the FCC's policy requirements. The plan that was devised involved installing GIS software capable of locating the position of a wireless caller. microDATA GIS's application called ALI-Trakker provides the location of landline and wireless callers on a map display. This allows dispatchers to more effectively help callers in their time of need. Their plan has been implemented and the software is installed. Kingsport exhibited great public due diligence by acknowledging the wireless E911 problem early on and creating a plan that implemented a solution. Kingsport should be applauded for their efforts to implement a wireless E911 solution.

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Introduction

Our society is increasingly becoming more mobile. This is evident by the popularity and increasing use of cell phones. The number of cell phone users and the calls they make each day is staggering. Cellular Telephone Industry Association (CTIA) is the international association for the wireless telecommunications industry. They estimate there are over 171 million cell phone subscribers in the United States alone. CTIA also estimates that 46 thousand new wireless phone subscriptions are made each day. For many cell phone users one of the main purposes for owning one is for safety reasons. "The marketing strategy includes the sale of "security" to the helpless motorist stranded at night on a rainy back road. The economic reality is that they can sell this service at a reasonable rate, give away the telephone itself, and realize a profit from the whole enterprise" (Ozanich 106). Although wireless phones can be an important public safety tool, they create unique challenges for public safety, emergency response personnel, and for wireless providers. "The cellular user has limited knowledge of telecommunications, and even less awareness of the functional aspects of 911 data systems. They expect that their wireless telephone will produce the same result as a wireline telephone when 911 is called" (Ozanich 112). Wireless 911 calls do not relay critical information that dispatchers are accustomed to receiving from a landline phone. Unlike a landline phone, a cell phone is inherently mobile and not associated with a fixed address or location. Emergency communications centers across the nation are currently facing the daunting task of implementing new wireless enhanced 911 systems that will solve the issues surrounding emergency wireless calls. Kingsport, Tennessee's Emergency Communications Center has been proactive about wireless enhanced 911 concerns. With the help of Kingsport's Geographic Information System (GIS) Division, they have implemented a solution to locate wireless 911 callers as well as enhance the current landline 911 system. I am a GIS Analyst with Kingsport's GIS Division and was privileged to be involved with implementing the wireless 911 mapping solution used in the Emergency Communications Center.

Landline E911

In order to understand the intricacies of implementing a wireless enhanced 911 solution, it is necessary to first have a basic understanding of how a landline 911 system functions. In a basic landline 911 system only a voice connection is routed to a predetermined Public Safety Answering Point (PSAP). Emergency responders do not gain any information other than what is provided by the caller.

The emergency and its location are communicated by voice between the caller and the call taker. It wasn't until the introduction of Enhanced-911 (E911) that the caller's location and originating telephone number were automatically detected by equipment at the PSAP. Landline E911 uses the caller's telephone number as an automatic location information (ALI) record to route the call to the correct PSAP. The ALI record is used to retrieve data that provides the PSAP with specific information about the caller. Equipment and database information must be installed at the PSAP that allows the call taker to see the caller's phone number and location address on a display. For years now, landline E911 has been providing accurate data to trained call takers at PSAPs across America. This system has proven to be very effective in providing dispatchers with pertinent information in a timely manner. When a citizen is in need of an emergency response due to injury, illness, fire, or crime, they can dial 911 from their landline telephone and be confident that the emergency dispatcher taking their call will automatically receive their name, address, and phone number. In an emergency every second counts. "A 911 call taker's biggest challenge is to get an accurate location from the screams of disoriented, incoherent, or panicky callers. 911 personnel can start units rolling to the scene – if they know where to go – even before all the details of an incident are known. That can shave seconds and minutes from response time: that can save lives" (Kauffman 16). E911 has been shown to reduce response times. If the caller is unable to speak, does not know where they are, or does not know their phone number the enhanced function of the 911 system can be the difference between life and death.

Wireless 911 Problem

Unfortunately, the rapid proliferation of wireless phones has reduced the efficacy of the E911 system. "What is simultaneously happening to the Enhanced 911 system is that we no longer have reliable location information about all of our callers. Instead of only 1% of error in our ability to deliver correct location information, we are seeing an increase in the error rate because more and more people are calling 911 from wireless devices that are never in the same place for very long" (Ozanich 106). "It is estimated that of the 150 million calls that were made to 911 in 2000, 45 million of them were made by wireless telephone users—that's 30 percent. This is a ten-fold increase from nearly 4.3 million wireless 911 calls just 10 years ago, and the number will more than double to 100 million calls in the next five years. It is anticipated that by 2005, the majority of 911 calls will be from wireless callers" ("Wireless Statistics"). Kingsport Tennessee's Emergency Communications Center can relate to these figures. Donna Carrier is the Emergency Communications Manager there. She reports that in 2003, 48,784 911 calls were received at the dispatch center. Of those 20,095 were made by a cell phone. That is equivalent to 41% of the total 911 calls made in Kingsport. So far the numbers for 2004 are much the same. In the last ten months 39,429 911

calls have been received at the dispatch center. Of those 17,279, or 44%, have been made by a cell phone.

The majority of the problems associated with wireless 911 calls stems from a cell phone's inability to provide emergency dispatchers with specific enhanced 911 information in the same manner that landline phones do. Because wireless telecommunications are inherently mobile, a cell phone caller's location information is no longer associated with their telephone number. This has created numerous problems for dispatchers and emergency response personnel. When dispatchers do not automatically receive an ALI record the dispatcher does not know the caller's location, name, or call back number. The lack of location information has led to dramatic and detrimental outcomes for some users who were unable to describe where they were or were physically unable to communicate. These non-enhanced wireless 911 calls are overtaxing the resources of PSAPs. Because dispatchers have to spend extensive time and effort to identify the caller's location through alternative techniques, precious emergency response time is lost. "It is no surprise that wireless calls are, on average, four times the length of a landline call" (microDATA GIS 5).

FCC Rules and Regulations

After receiving wireless 911 calls for several years without any associated data, the public safety community banded together in 1994 to lobby the Federal Communication Commission (FCC) for service parity between existing landline E911 systems and wireless systems. The FCC recognized that the non-enhanced wireless 911 calls were eroding the ability of emergency services to locate callers and ensure timely arrival of help. Since the 911 network is a vital part of the U.S.'s emergency response system, something had to be done to fix the wireless 911 issues. The FCC responded by creating rules and regulations that require wireless telephone carriers to provide E911 capability.

The challenge in integrating landline and wireless E911 systems is to provide the PSAPs with the same information they are accustomed to receiving from the landline systems. "The Federal Communications Commission (FCC) has taken a number of steps to increase public safety by encouraging and coordinating development of a nationwide, seamless communications system for emergency services that includes the provision of location information for wireless 911 calls" ("Wireless 911"). One of these steps was the enactment of the Wireless Communications and Public Safety Act in 1999. "The law was enacted to promote and enhance public safety through the use of 911 as the universal emergency assistance number, further deployment of wireless 911 service, support of States in upgrading 911 capabilities and related functions, encouragement of construction and operation of seamless, ubiquitous, and reliable networks for personal wireless services and for other purposes" (Hatfield 7). It was recognized

early on that the technical challenge involved in completing such a task would require an approach that phased in the changes and mandates over time.

Wireless 911 Phases

There are three phases required to implement a wireless 911 solution. Phase 0 is the most basic. It requires that when a caller dials 911 from a cell phone the call will be transmitted to a PSAP regardless of whether the caller is a wireless service subscriber or non-subscriber. The actual call taker could be at a state highway patrol office or at a city or county PSAP hundreds of miles away depending on how the wireless 911 call is routed.

Phase 1 is the next step. In comparison, Phase 1 provides better emergency response service to wireless 911 callers than does Phase 0. During Phase 1 deployment the PSAP's wireless jurisdictional boundaries are established for each cell tower sector. This allows for the caller to be directed to the appropriate PSAP according to the cell sector that is delivering the call. After Phase 1 has been implemented, a wireless 911 call will enter the PSAP with its associated call back number. This information can be used if the 911 call is dropped. Also, the location of the cell tower and the cell sector the call is being delivered from is forwarded to the PSAP. This information can be used to provide a very general indication of the location of the wireless caller. Although this information can be beneficial, is not specific enough for either dispatchers or emergency rescue personnel to know the exact location of the caller in order to provide quick and efficient assistance.

The last phase required by the FCC is Phase 2. In addition to Phase 1 information, once implemented, Phase 2 provides call takers with the geographic latitude and longitude coordinates of the wireless caller. When Phase 2 data is combined with a mapping display at a PSAP the location of a wireless 911 caller can be determined. In the event a caller's Phase 2 location information cannot be determined the system will revert to relaying Phase 1 data.

Positioning Determining Entity Types

A Positioning Determining Entity (PDE) must be implemented into the wireless infrastructure to determine and provide the caller's geographic location information. The FCC has defined three types of PDEs. They include: network-based solutions, handset-based solutions, and a combination of both technologies. The wireless carrier determines which solution to install on their infrastructure in order to deliver Phase 2 data to the PSAP.

In a network-based approach the components that determine the caller's location are embedded into the wireless network. The advantage here is that nothing needs to be added to the phone. This means that all older phones will work with this

type of solution and that a new phone is not required in order to receive service. The basis for receiving location information from this type of solution is built around triangulation. Usually three or more cell towers are used to compare arrival times of the handset's signal. Calculations are made from these arrival times to determine the caller's location within the cell sites network.

In a handset-based application the location determining components are embedded into the wireless device itself. Handset-based wireless devices use Global Positioning Satellites (GPS) technology to relay location data. A GPS receiver is added to a cell phone, which collects signals from satellites. The handset uses this information to calculate the caller's position by using known elements of velocity, time, and distance. This method is considered to be the most accurate. The drawbacks are that GPS signals tend to be weak on the Earth's surface, cannot penetrate buildings, and vary in accuracy depending on weather conditions. Another disadvantage of this solution is that it requires a user's phone to be GPS enabled. Older phones do not have this technology built into them so many users would need to purchase a new GPS enabled phone to receive the benefits of handset-based applications.

The FCC also implemented accuracy and reliability requirements as part of its wireless E911 service. In a network-based solution calls must be accurate to within 100 meters for 67 percent of calls and within 300 meters for 95 percent of calls. For a handset-based application calls must be accurate to within 50 meters for 67 percent of calls and 150 meters for 95 percent of calls.

FCC Provisions

Before a PSAP can receive Phase 1 and Phase 2 service they must first have the infrastructure and hardware that is required for the service. A provision to receiving wireless E911 services, as mandated by the FCC, is dependent on the readiness of the individual PSAPs ability to receive data in the specified format. Before Phase 1 or Phase 2 services can be implemented at the PSAP issues such as administrative, operational, and technical must be addressed. The FCC requires that the PSAP be capable of receiving and using both Phase 1 and Phase 2 data and also have a mechanism in place to pay the costs associated with the services. The deployment of wireless E911 is dependant on the development and installation of new technologies and upgrades to local 911 PSAPs. This requires coordination among public safety agencies, wireless carriers, technology vendors, equipment manufacturers, and local landline telecommunication carriers. The technological solution chosen to implement Phase 1 and Phase 2 service is dependent on the PSAPs existing E911 infrastructure, the wireless service provider's technology, and the budget of the PSAP. Each PSAP must declare themselves ready to receive the data before the wireless carriers are obligated to provide the service to them. Once the necessary upgrades have been made, the

FCC mandates that wireless carriers have six months to provide wireless E911 information to the PSAP unless a waiver is granted to the wireless carrier for an extension of the deadline. Because of the cost to the wireless providers to upgrade their infrastructure and the time that is involved in doing so, several wireless carriers have applied for and received extensions to the deadline.

GIS Mapping Solutions

It has been said that a picture is worth a thousand words. In public safety a picture can actually help save lives. Geographic Information System (GIS) based mapping solutions are allowing PSAPs to locate callers faster and manage tasks more efficiently. “Wireless communications and the problem of specifically locating an individual placing a 911 call through a wireless device appears to be a challenging new application for GIS. Location determination technologies have been developed that allow for the identification of a coordinate on Earth’s surface using global positioning satellites, radio frequency measurement, signal strength, triangulation, and other methods. Once a coordinate location can be established the point can be displayed on a digital map base” (Ozanich 114). The benefits of what GIS mapping means to a PSAP are evident due to the phenomenal growth of wireless callers and the FCC’s rules and mandates concerning wireless E911 Phase 1 and Phase 2. A GIS mapping system can overlay a cell tower’s sector coverage during a Phase 1 call. This allows the call taker to visually narrow down the exact location of a caller into a more general area. During a Phase 2 call a GIS mapping system is even more accurate. It takes the caller’s longitude and latitude and automatically zooms to the specific coordinates on a map display. This allows the dispatcher and emergency responders to focus on the details of the emergency instead of wasting time attempting to locate the caller first.

Kingsport GIS

Making the right decision on what type of mapping system to choose is difficult due to the number of variables and requirements that each PSAP faces. The final decision on what mapping system to implement must be based on the needs of the PSAP. The system must be able to support all the services that are currently being performed by the PSAP as well as include the ability to locate wireless and landline callers. Making the decision to implement an E911 mapping solution at a PSAP requires an understanding of what will be necessary to execute such a decision.

Mapping for E911 involves much more than just simply adding a map display to the traditional call taking equipment at a PSAP. It is impossible to discuss the installation of a mapping display without considering the source of data that will be utilized by the application. An E911 mapping solution is dependent on the availability of high quality spatial data. In addition to displaying a map, implementation of E911 mapping requires data creation, GPS data collection and

verification, GIS maintenance, ALI/GIS synchronization, and data preparation. The GIS data that appears on the call taker's screen must be constantly maintained and updated in order to properly model the real world. Additional needs for transferring data and capturing GIS and wireless discrepancies will need to be addressed before the introduction of E911 mapping software in the PSAP.

It is not typical for every PSAP to have access to GIS resources. This was not the case for the PSAP in Kingsport, Tennessee. Fortunately, the City of Kingsport had an established GIS Division already in place. As an employee of the city's GIS Division, I was involved with implementing E911 mapping into Kingsport's PSAP. The Kingsport GIS division serves as the agency responsible for providing GIS data to the PSAP. Many of the most important GIS layers had already been created and maintained by the city's GIS division. By having an in-house GIS division, we are able to ensure the completeness of the data, the quality of the data, and have the ability to maintain the data in a timely fashion. Maintaining the GIS data is a critical element to the success of E911 mapping. It cannot be overstressed that in a project where lives and property are at stake, quality assurance in every phase of the project is of the utmost concern. As new building permits and addresses are added, new roads are built, or address problems are discovered someone needs to keep all the GIS data accurate and consistent. Because of this, a constant flow of data moves between the GIS division and the PSAP.

Kingsport's Mapping Solution Vendor

When Kingsport's Emergency Communications Board set out on finding a vendor to provide E911 mapping software they found many capable companies that were interested in the opportunity. After several site visits to other PSAPs to see different vendors' products in action and much deliberation, they decided on a suite of applications produced by microDATA GIS. microDATA GIS was established in 1983 as a solutions provider for GIS data development and software for 911 and public safety agencies throughout the United States. microDATA GIS produces a suite of software that is designed specifically for E911 database development and maintenance. microDATA GIS has divided their suite of applications into two primary groups: Back-Office and Front-Office. The Back-Office applications are built to provide efficient error-free data preparation, connectivity with outside data sources, and elimination of multiple error-prone procedures. The Front-Office application runs at the call-taker workstations. It is built for speed, reliability, compatibility with coexistent software, and ease-of-use. microDATA GIS' integrated approach connects the Front-Office to the Back-Office. It produces high quality GIS data that is pre-synchronized with the telephone company's ALI database. Their software also implements ways of easily updating and transferring the data to the PSAP for the map display.

microDATA GIS Applications

microDATA's Back-Office products e9collector, e9GIS, and ALI-Auditor were used by Kingsport to develop and maintain the three primary GIS layers needed to implement the mapping application. Those layers are: address sites, geocoded roads, and the areas served by each road. Although Kingsport's GIS division already had many of the layers necessary to implement mapping in the PSAP we lacked one of the primary layers. We did not have any address sites for the city. We used e9collector to build this data from scratch. E9collector is integrated with a real-time GPS unit that allows one to accurately map features in the field. I used this application to field verify and map every address within the corporate limits of Kingsport. This process took approximately ten months to complete. When I finished I had collected almost 20,000 individual address sites.

Throughout the process of field verification we also utilized an application called e9GIS. microDATA created e9GIS for 911 coordinators who are tasked with the responsibility of building GIS information. We use this application to properly build and maintain GIS data layers such as road centerlines and address sites. It uses microDATA's patented Road Access Zone (RAZ) technology to create zones around each intersecting section of road. The technology assures that all address sites are properly addressed and that the road geocoding will be accurately maintained. E9GIS is also used for data audits. It can produce error reports that identify problems such as misnamed roads and address parity issues.

ALI-Auditor was used to synchronize the GIS address sites and road data to the telephone company's ALI and Master Street and Address Guide (MSAG) databases. It was important to synchronize the different data sources because they were created and maintained independently from one another. The GIS data that I verified and collected in the field was used to pro-actively root out discrepancies between the GIS data and ALI database. This process helped to ensure that every address record in the telephone company's ALI database had a corresponding address site in the GIS data. This had the effect of removing potential errors before they became a problem during a 911 call at the PSAP.

microDATA's Front-Office product called ALI-Trakker is the actual mapping application used by the call takers in Kingsport's dispatching center. It integrates with their existing software and hardware that is used to receive calls and dispatch emergency response agencies. In the event of a wireless Phase 1 call, ALI-Trakker zooms to the cell sector coverage area of the tower that is transmitting the call. It will calculate all the roads covered by the cell sector and return a list of possible roads the caller may be on. For a Phase 2 call, ALI-Trakker zooms to the coordinates of the caller and displays a cellular icon on the map display. It will also return a list of all the address sites within an accepted error distance of the

wireless caller. With the caller's location identified, the dispatcher is able to quickly identify which emergency agency should respond to the incident.

ALI-Trakker also has the ability to add other data to the map screen that can be very beneficial to the dispatchers. Kingsport's PSAP can view many additional features such as: aerial photography, fire hydrants, school grounds, interstate mile markers, county boundaries, parks, Kingsport's Greenbelt and its associated distance markers, water tanks, water pump stations, and hydrologic features like the Holston River and area creeks. As an added benefit, ALI-Trakker has the ability to use tool tips that allow the dispatcher to simply hover over a feature with the mouse or use a select feature tool to identify attributes about the feature. For example a dispatcher can hover over a fire hydrant and a tool tip label will automatically display the amount of gallons of water per minute the particular hydrant will flow. This information can be used to quickly relay the location and the flow capacity of a fire hydrant to a firefighter at the scene of an emergency. In another example, the dispatcher could use the select tool to select an address site and see a description about the house or business in question. The description about the site was created when I field verified the address of the structure. ALI-Trakker also includes several search tools that are valuable to the dispatcher. For example, a dispatcher could search for a specific address by typing it into an address search box. They could also locate a specific street or intersection by typing in the name of it in the street search dialog box. One other feature of ALI-Trakker is the ability to show geographic coordinates, in several different formats, for any location on the map. Dispatchers can use this information to advise helicopter air rescue units of landing location coordinates.

Kingsport uses microDATA's AT-Store application to push data updates and application configuration changes to the six call taker stations in the dispatch center. Since the GIS division and emergency communications center are located in different buildings, this feature greatly increases the ease and efficiency by which data is maintained and transferred on a regular basis. By using a central database server, communications network, and virtual network connection (VNC) technology, GIS data can be copied into one directory on the AT-Store machine and all of the call taker positions will be automatically updated. The system also has the ability to track discrepancies between the telephone company's ALI database and the GIS data. These errors can be passed back to the communications director or 911 coordinator for correction.

Expenditures

In Kingsport, the wireless 911 solution was implemented in two stages. Stage 1 consisted of microDATA's back-office applications, data verification, and data creation. The total expenditure for stage 1 was \$45,710. That included the software, training, consulting, data preparation, supporting programs, Sprint ALI

database download, and hardware such as a laptop, GPS unit, and laser range finder. Stage 2 of the project was the installation of microDATA's front-office applications in the dispatch center. The software was installed on six call stations in the dispatch center. Training was provided by microDATA on the use of the application. The total expenditure for stage 2 was \$47,068.75. The grand total to implement the wireless 911 mapping solution was \$92,778.75. The mapping solution was paid for by the 911 excise tax the Kingsport Emergency Communications Board receives from landline and wireless phone users. The State of Tennessee has a grant program available to emergency communications districts that are FCC Phase 2 compliant. Kingsport applied for the state's wireless 911 grant program and received \$50,000. They applied this allocation of funds towards the debt incurred during the implementation process. The state grant recognizes the importance of data maintenance and update. As part of the grant, Kingsport's Emergency Communications Board receives \$10,000 annually for the cost involved to continually maintain and update the data used by the mapping application in the dispatch center.

Conclusion

In an emergency situation every second counts. This is why it is so important for 911 call takers to know the caller's location so that help can find them as quickly as possible. The lack of landline and wireless E911 parity has caused a great void in the reliability of the nation's emergency response system. This problem has been thrust into the spotlight by the deaths of several callers whose lives could have been saved had wireless E911 been implemented. The technology to locate wireless 911 callers exists. Unfortunately, the technology is not yet in place throughout the country. The majority of citizens in the United States are still largely unaware that their wireless phones do not provide enhanced 911 features. They are dependent on the public safety community to make the necessary improvements that will ensure help will indeed be on the way when 911 is dialed from a cell phone. Kingsport exhibited great public due diligence by acknowledging the wireless E911 problem early on and creating a plan that implemented a solution. They faced the wireless E911 challenge head on and were among the first emergency communications districts in Tennessee to implement such a solution. Kingsport should be applauded for their efforts to implement a wireless E911 solution.

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